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MERIT COMPARISONS OF THE SERIES 64 HIGH-SPEED DISPLACEMENT HULL FORMS

Eugene P. Clement

HYDROMECHANICS LABORATORY

RESEARCH AND DEVELOPMENT REPORT

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MERIT COMPARISONS OF THE SERIES 64
HIGH-SPEED DISPLACEMENT HULL FORMS

by

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NOTATION

A	Sectional area
A_X	Maximum sectional area
B	Breadth on waterline
B_X	Breadth on waterline at maximum sectional area
C_B	Block coefficient
C_P	Prismatic coefficient
C_f	Coefficient of frictional resistance
ΔC_f	Correlation allowance
C_r	Coefficient of residual resistance, $R_r / \rho/2\ Sv^2$
g	Acceleration due to gravity
H_X	Draft at maximum sectional area
L	Length on waterline
LCB	Longitudinal location of center of buoyancy
LCF	Longitudinal location of center of flotation
R	Total resistance
R_f	Frictional resistance
R_r	Residual resistance $(R - R_f)$
S	Area of wetted surface
V	Speed in knots
v	Speed
W	Gross weight in pounds
Δ	Gross weight in tons
∇	Volume of displacement
ρ	Mass density of water

Subscripts:

m	Model

ABSTRACT

Values of residuary resistance from model tests were previously presented for a methodical series of slender displacement hull forms which had been tested up to high speeds. The present report gives values of total resistance for the hull forms of the series so that their relative merits can readily be seen. The values of total resistance were calculated for boats of 200-ton displacement to facilitate comparison with resistance data for U. S. Navy hydrofoil boats. The form of the data presentation is such as to provide guidance for the design of high-speed displacement and catamaran hull forms.

INTRODUCTION

Reference 1* presented the results of model resistance tests of a methodical series of slender displacement hull forms designed for operation at high speed. Twenty-seven models were tested in the series, which was designated DTMB Series 64. The purpose of the work was to provide information for guidance in designing efficient high-speed displacement hulls and also to provide data for evaluating the performance of other designs of fast craft.

The results of the tests of the Series 64 hull forms are presented in Reference 1 as values of residuary resistance coefficient and values of residuary resistance per ton of displacement. Values of wetted surface and wetted-surface coefficient are also given so that the resistance of a ship of any size can readily be calculated from the results of any one of the model tests. However, values of total resistance for the hull forms tested are not given in Reference 1, and therefore the relative merits of the different designs of the series are not readily apparent.

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* References are listed on page 7 .

In the present report comparisons of the total resistances of the hull forms of Series 64 are presented so that the relative efficiencies of the different hulls can be readily seen. It was necessary, to calculate values of total resistance, to make a selection of the size of the full-scale craft to which the model resistance values were to be converted. For this report, the resistance values from the tests of the models of Series 64 were corrected to correspond to a boat having a gross weight of 200 tons. This was done so that the resulting resistance values could conveniently be compared with resistance values for the Navy's hydrofoil boats. [The average of the displacements of the first two large-scale Navy hydrofoil boats, PC(H) and AG(EH), is approximately 200 tons.] Also the data are presented in such a form as to provide guidance for designing displacement and catamaran-type hull forms for low drag.

THE HULL FORMS OF SERIES 64

As explained in Reference 1, the hull forms of the series were derived by first developing an efficient parent form, and then making systematic variations of the most significant hull form parameters. The lines and hull form coefficients for the parent form are shown in Figure 1. The parameters selected for variation in deriving the hull forms of the series were block coefficient, beam-draft ratio, and displacement-length ratio [$\Delta/(0.01L)^3$]. Three values of each of these parameters were selected and all possible combinations were tested; accordingly there were 27 models in the series.

The values of block coefficient selected for testing were 0.35, 0.45, and 0.55; the values of beam-draft ratio were 2, 3, and 4. The range of values of displacement-length ratio varied with block coefficient. The values are given in Table I. The curves of sectional area and of ratio of local waterline breadth to breadth at the maximum section are shown in Figure 2. These curves apply to all the models of the series.

The waterline length of each of the models was 10 feet. Other model dimensions are given in Table II. The form parameter having the most

pronounced effect on model shape was the block coefficient. Body plans for three representative models (one for each value of block coefficient) are shown in Figure 3. Body plans for all the models, and also values of additional coefficients of form, can be found in Reference 1.

METHOD OF RESISTANCE COMPUTATION AND FORM OF DATA PRESENTATION

Values of speed and resistance from the tests of the 27 models of Series 64 are given in Table III. The air drag of the towing gear has been subtracted from the measured resistance values.

For this report the model values of speed and resistance were corrected to full scale for a boat weight of 200 tons. The 1947 A.T.T.C. friction coefficients and the standard correlation allowance (ΔC_f) of 0.0004 were used in correcting the values of model resistance to full scale. The full-scale values of resistance and speed were then converted to the dimensionless form of R/W and F_∇ (equals $v/\sqrt{g\nabla^{1/3}}$). (Figure 4 shows the relationship of F_∇ to speed and displacement.) The values of R/W and F_∇ were next plotted for each model and curves were faired through the spots. Examples of these plots for three of the hull forms of the series are shown in Figure 5. Values of R/W for evenly spaced values of F_∇ were then rea off the curves. These values are plotted against slenderness ratio in Figure 6. (The relationship between slenderness ratio and displacement-length ratio is shown in Figure 7.) Each section of Figure 6 presents values of R/W for the 27 models of the series, at a particular value of F_∇ . This method of presentation is such that the relative resistances of the different hull forms are compared on the basis of equal speed, equal gross weight, and equal length. The relationship of $L/\nabla^{1/3}$ to length and displacement is shown in Figure 8. As an example of the use of Figures 4, 6, and 8, consider the problem of designing a 200-ton boat which is to have a speed of 45 knots. Figure 4 indicates that the value of F_∇ corresponding to this displacement and speed is approximately 3.0. Accordingly, the upper part of Figure 6b can be used

to determine values of resistance/weight ratio for a range of values of block coefficient, beam-draft ratio, and hull length. A hull length of 180 feet gives, from Figure 8, a value of $L/\nabla^{1/3}$ equal to 9.4, and the top part of Figure 6b then indicates that with this value of slenderness ratio, a block coefficient of 0.45, and a beam-draft ratio of 2, the resistance will be approximately 10 percent of the gross weight. With the same slenderness ratio and block coefficient, and a beam-draft ratio of 4, the resistance will be 11 percent of the gross weight. If the length is increased to 210 feet, then from Figure 8 $L/\nabla^{1/3}$ equals 11.0. In this case the upper part of Figure 6b indicates that a block coefficient of 0.45 and a beam-draft ratio of either 2 or 3 will result in a value of resistance equal to about 9.5 percent of the gross weight. The same graph shows that a block coefficient of 0.35, together with a beam-ratio of 4, would result in a value of resistance equal to 12 percent of the gross weight, which is 2 [redacted] percent higher than the resistance value just mentioned.

It should be evident that although it was necessary to select a specific displacement in order to calculate the values of total resistance, the graphs presented here are nevertheless applicable for design studies of boats of a fairly wide range of displacement both above and below 200 tons. To illustrate this point, Figure 9 compares data from a representative model of the series (Model 4797) as corrected to a boat weight of 200 tons, and as corrected to a boat weight of 50 tons. In this typical instance the difference in resistance/weight ratio for most of the speed range is about 5 percent. Figure 10 presents values of the ratio of R/W for various displacements to R/W for 200 tons displacement (again from the test of Model 4797). Figure 10 indicates that if the values of resistance/weight ratio in this report (which have been calculated for a boat weight of 200 tons) are used to determine the resistance of a boat having a gross weight of 100 tons, the value will be too low by about 2 1/2 percent. This results from the fact that the frictional resistance coefficients increase with a decrease in size and a corresponding decrease in Reynolds numbers. However, the graphs in this report are intended to be useful chiefly as an aid to selecting coefficients of form that will

result in efficient designs. It will be evident that their usefulness for this purpose will cover a wide range of displacements above and below 200 tons. Assume, for example, that we wish to design an efficient hull form for a boat having a gross weight of 100 tons. If we consider the result of adjusting the values of resistance/weight ratio corresponding to 200 tons so that they correspond to a gross weight of 100 tons, it is evident that all the values will be increased by about 2 1/2 percent. Accordingly, the relative resistance values will evidently not be significantly changed. Therefore, we are led to the conclusion that it is not necessary to convert the data for 200 tons to each particular design displacement in order to use the Series 64 results as presented here for designing efficient hull forms of a variety of displacements.

DISCUSSION OF THE RELATIVE RESISTANCES OF THE HULL FORMS OF SERIES 64

The graphs for F_∇ equals 1.0 and 1.5, in Figure 6a, indicate that at these low speeds the resistance is affected chiefly by variation in slenderness ratio (and therefore, displacenent-length ratio also). The other parameters of the series generally have considerably less effect on resistance. The fact that at these speeds the resistance of round-bilge boats is determined mainly by the value of slenderness ratio has been remarked on before (in Reference 2, for example). At higher values of speed (or F_∇), there is a considerable spread of the resistance values, and a clear indication as to the relative merits of the different values of block coefficient and of beam-draft ratio. The poor performance (i.e., high resistance) of the models with block coefficient equal to 0.35, is readily apparent. Also apparent is the consistent superiority of the models with block coefficient equals 0.45. The resistance values for block coefficient equals 0.55 lie between those for the block coefficients of 0.35 and 0.45 - which suggests that the optimum block coefficient lies somewhere between 0.45 and 0.55. The graphs of Figure 6 indicate a consistent decrease in resistance with decrease in beam-draft ratio. The extent to which beam-draft ratio can be decreased, however, is limited by stability considerations.

Figure 11 presents values of wetted-surface coefficient for the models of the series. This graph shows relative magnitude of wetted surface for boats of equal gross weight. It indicates clearly that for a given value of slenderness ratio (i.e., given length of boat), the hull forms of the series having a block coefficient equal to 0.35 have considerably larger magnitudes of wetted surface than the hull forms having block coefficients of 0.45 or 0.55. This difference in magnitude of wetted surface presumably is the chief explanation for the high resistance values of the 0.35 block hull forms.

The graphs of Figure 6 have indicated that the hull forms which are of particular interest, because of their low values of resistance, are the ones having a block coefficient of 0.45, and beam-draft ratio of either 2 or 3. Accordingly, a further analysis of these is offered by the graphs of Figure 12. In these graphs, the values of resistance-weight ratio are presented only for the more efficient models of the series (the values and the form of presentation are the same as in Figure 6). Also presented in each graph, however, are values of the ratio of frictional resistance to weight for the same efficient models of the series. The difference between the open symbols (R/W) and the filled symbols (R_f/W) is obviously R_r/W, which is the ratio of residual resistance to gross weight.

Figure 12 indicates roughly how far it is practical to go in reducing resistance by increasing slenderness ratio. The extrapolation lines drawn on the graph for F_∇ equals 3.5 indicate that slenderness ratio for minimum resistance will be about 13.5, and the corresponding minimum attainable resistance-weight ratio will be about 0.12. At this point the resistance is almost entirely frictional, and the wavemaking resistance is negligible, so that there is no possibility of additional improvement by further increase in slenderness ratio. A similar conclusion can be drawn from the graph for F_∇ equals 4. At this speed the optimum value of slenderness is again about 13.5, corresponding to a minimum attainable value of resistance-weight ratio of about 0.15.

Figure 12 is also of interest as a guide to the design of the individual hulls for high-speed displacement-type catamarans. Assume, for example, that

a 100-ton catamaran is to be designed for a speed of 40 knots. The displacement of each hull will be 50 tons; Figure 4 then shows that the corresponding value of F_∇ is approximately 3.5. The lower part of Figure 12b can accordingly be used to determine an appropriate length for the hulls. (It is assumed that the hulls are to be spaced far enough apart so that interaction effects are avoided.) As discussed previously, the resistance/weight ratio can be expected to be a minimum at a value of $L/\nabla^{1/3}$ of approximately 13.5. Accordingly, from Figure 8 the optimum length for each of the catamaran hulls is about 160 feet. The lower graph of Figure 12b also indicates that the value of R/W for this length is about 0.12. However, Figure 10 indicates that this value should be increased by 5 percent for a hull having a gross weight of 50 tons. Accordingly, the resistance of each of the hulls of the catamaran can be expected to be:

$$0.12 \times 1.05 \times 50 \times 2240 = 14{,}100 \text{ lb}$$

and the total resistance of the craft will be double this amount.

ACKNOWLEDGMENT

The author gratefully acknowledges the contributions of Mr. Charles W. Tate, who performed the essential tasks of preparing the graphs and the tables of this report.

REFERENCES

1. Yeh, H. Y. H., "Series 64 Resistance Experiments on High-Speed Displacement Forms," Marine Technology, Vol. 2, No. 3 (Jul 1965).

2. Nordstrom, H.F., "Some Tests with Models of Small Vessels," Publication No. 19 of the Swedish State Shipbuilding Experimental Tank (1951).

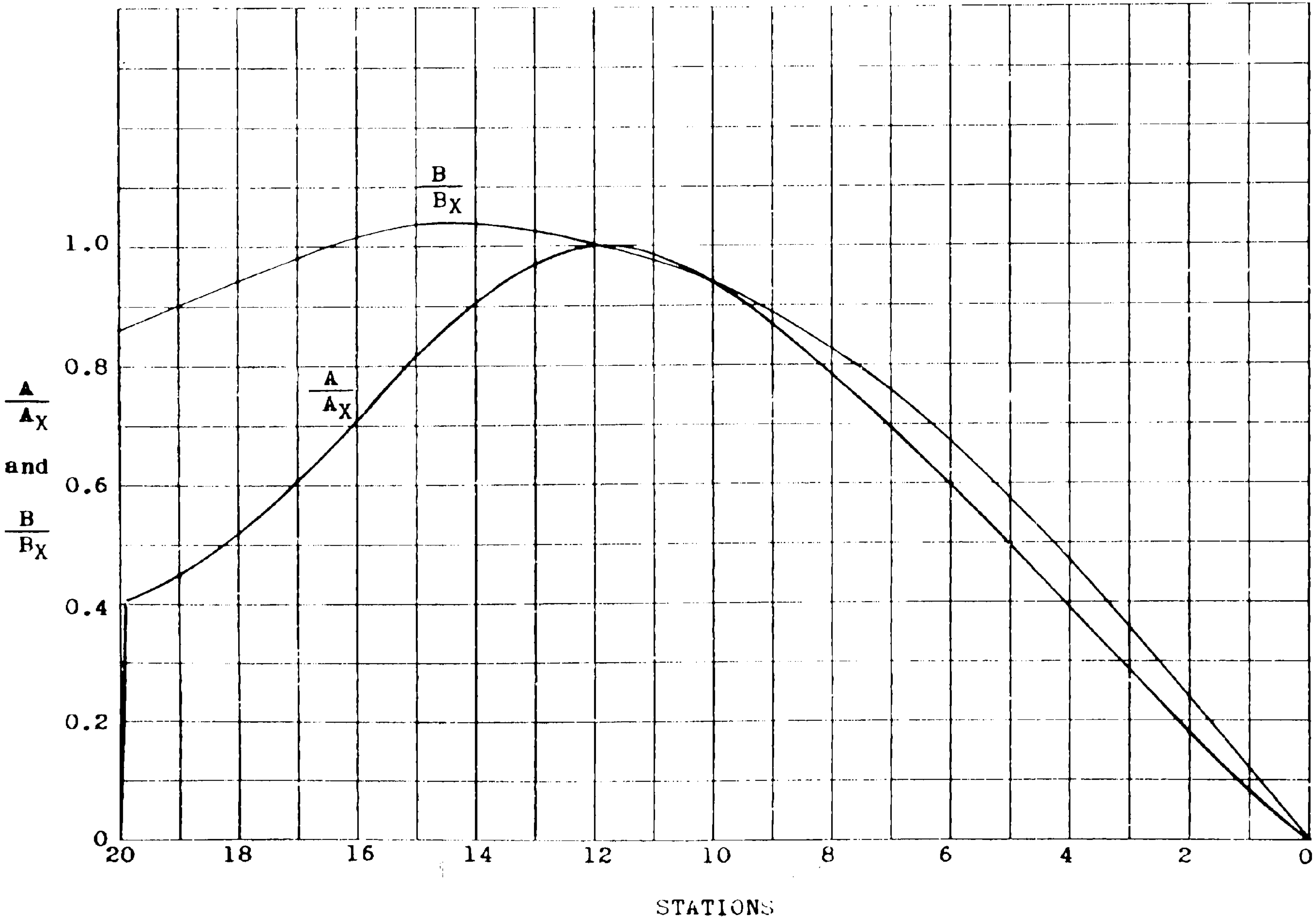
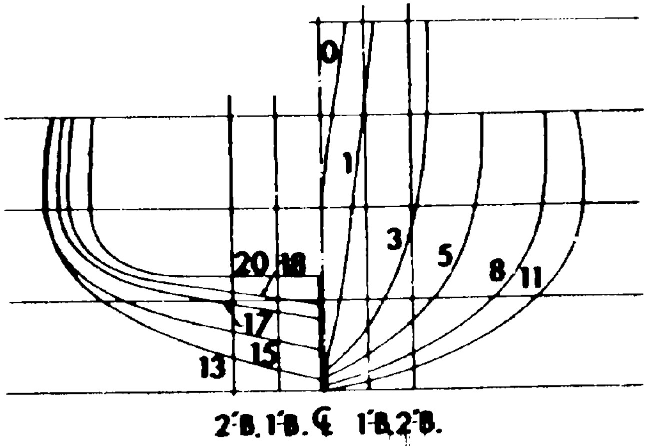


Figure 2 - Curves of A/A_X and B/B_X for the Models of Series 64

DTMB MODEL 4783-1



LWL Dimensions and Coefficients

L	10.00 ft
B_X	1.00 ft
H_X	4.00 in.
L/B_X	10.00
$L/\nabla^{1/3}$	8.72
C_B	0.45
C_P	0.63
C_W	0.76

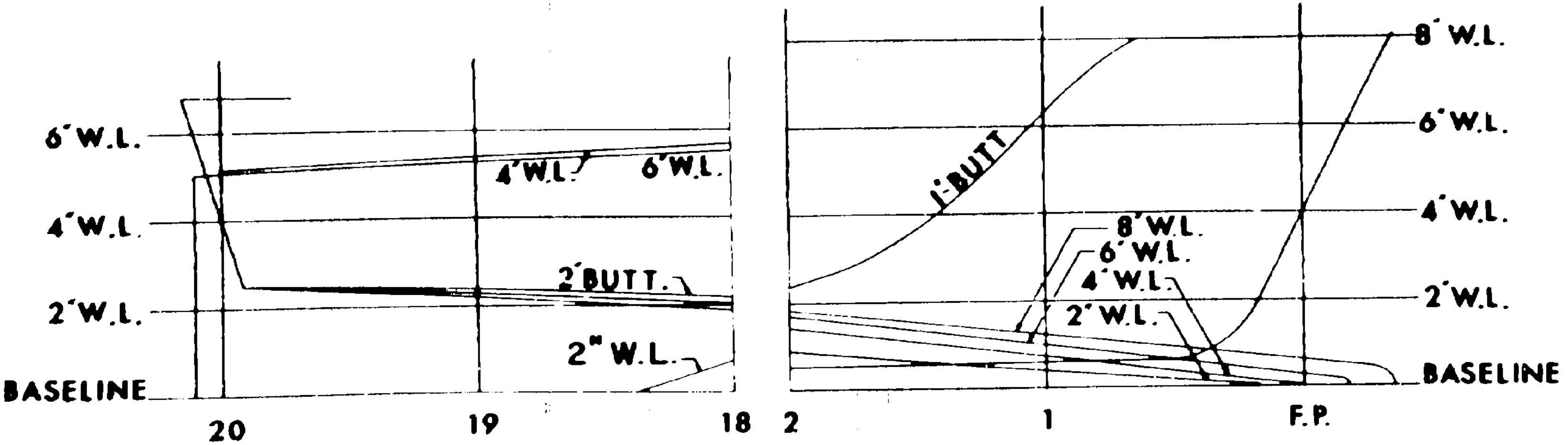


Figure 1 – Lines and Hull Form Coefficients for the Parent Model of Series 64

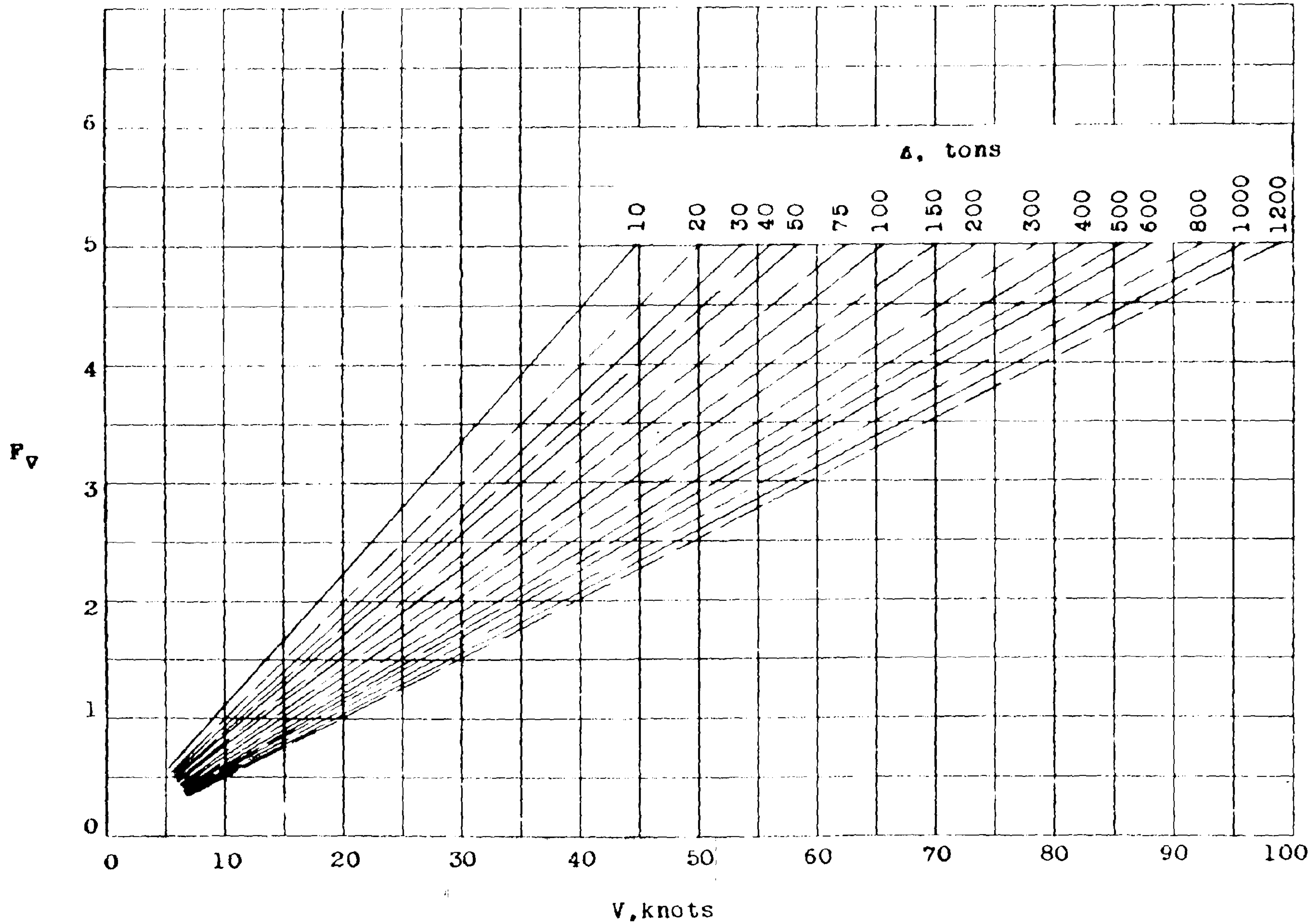
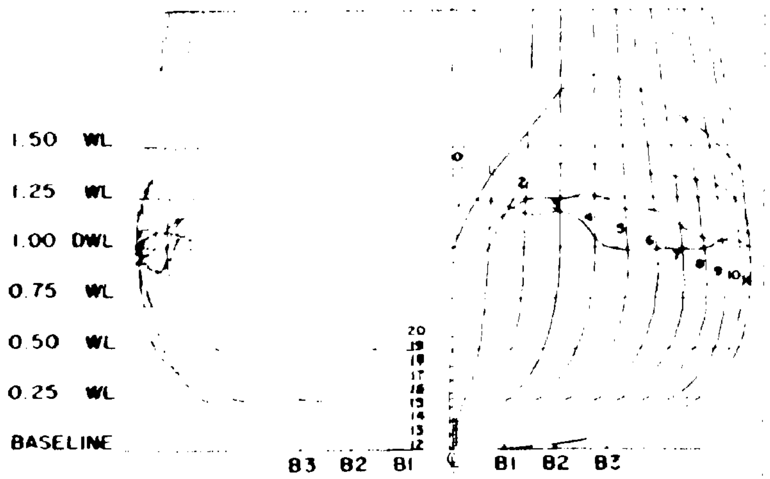
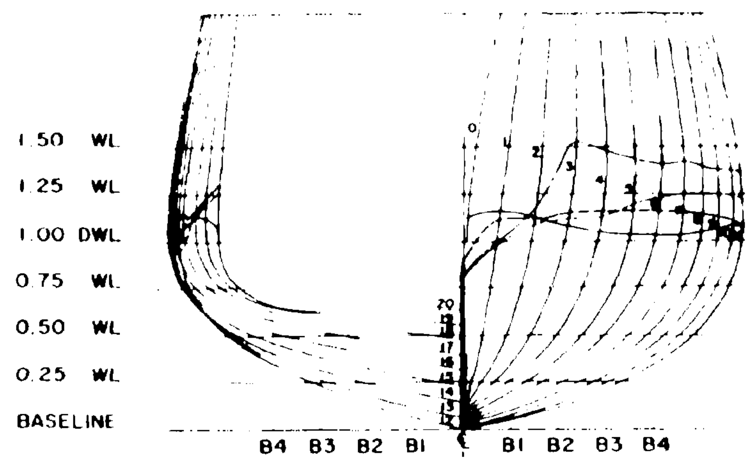


Figure 4 - Variation of Volume Froude Number with Speed and Displacement



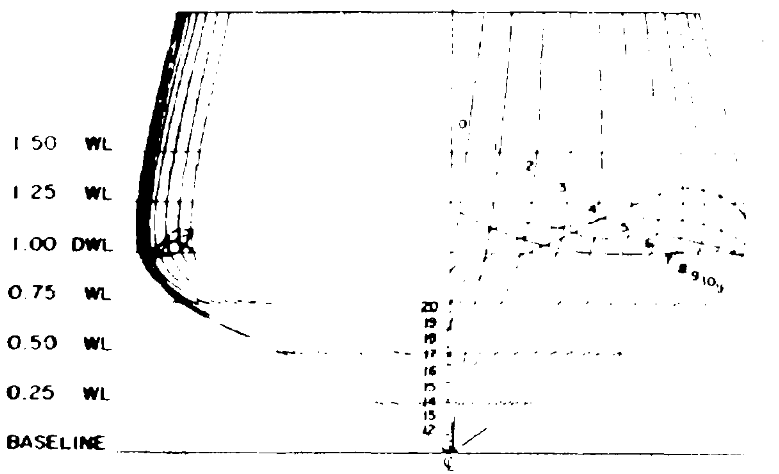
Model 4791 B/H 3

$C_B = 0.55, \quad \Delta/(0.01L)^3 = 40$



Model 4800 B/H 3

$C_B = 0.45, \quad \Delta/(0.01L)^3 = 32.5$



Model 4809 B/H 3

$C_B = 0.35, \quad \Delta/(0.01L)^3 = 25$

Wave Profile,

3 KNOTS
6 KNOTS
9 KNOTS
12 KNOTS

Figure 7 Body Plans for Three Representative Models of Series 64

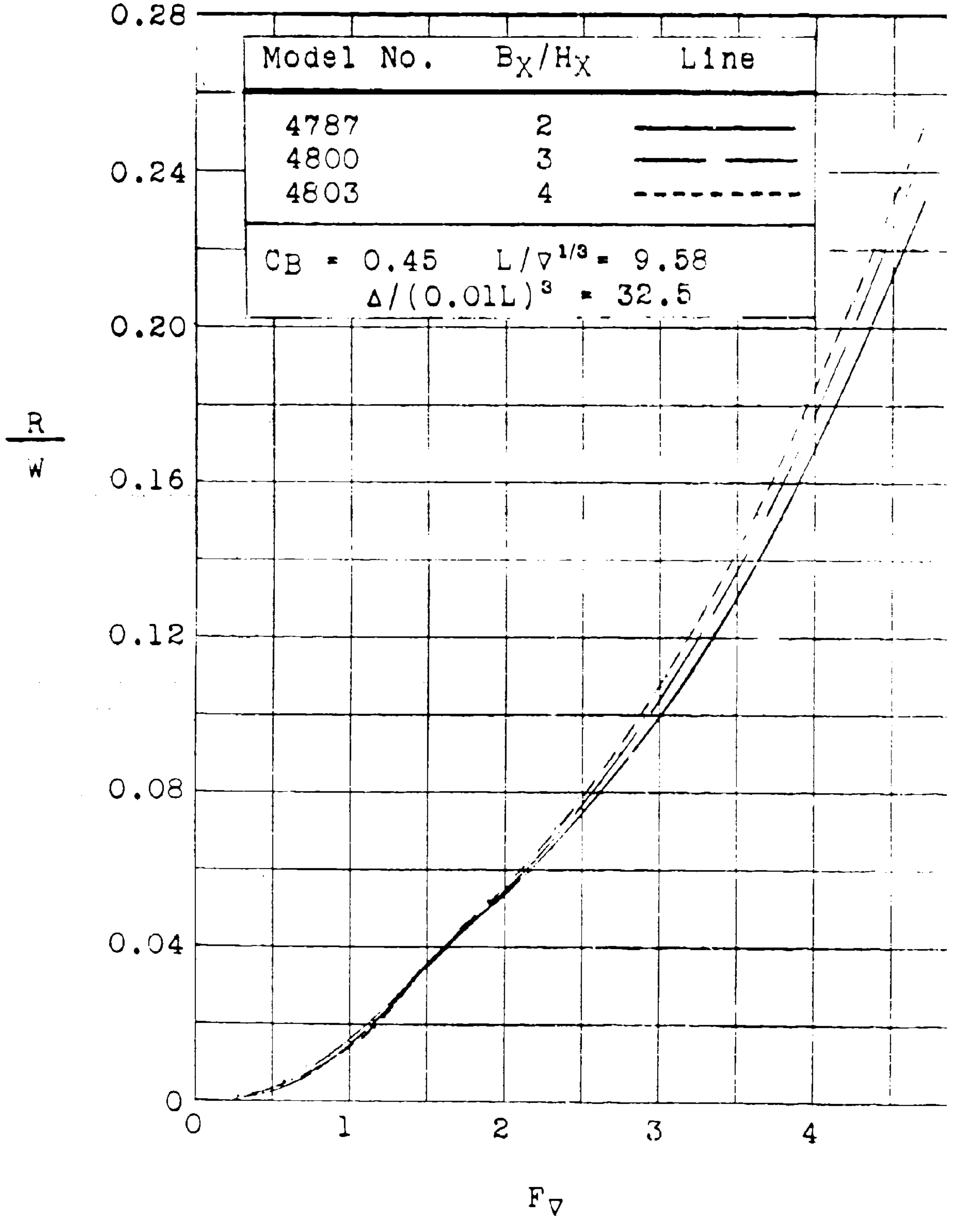


Figure 5 - Resistance-Weight Ratio versus Volume Froude Number for Three of the Hull Forms of Series 64. Resistance Values are for Boats of 200 Tons Gross Weight; ΔC_f = 0.0

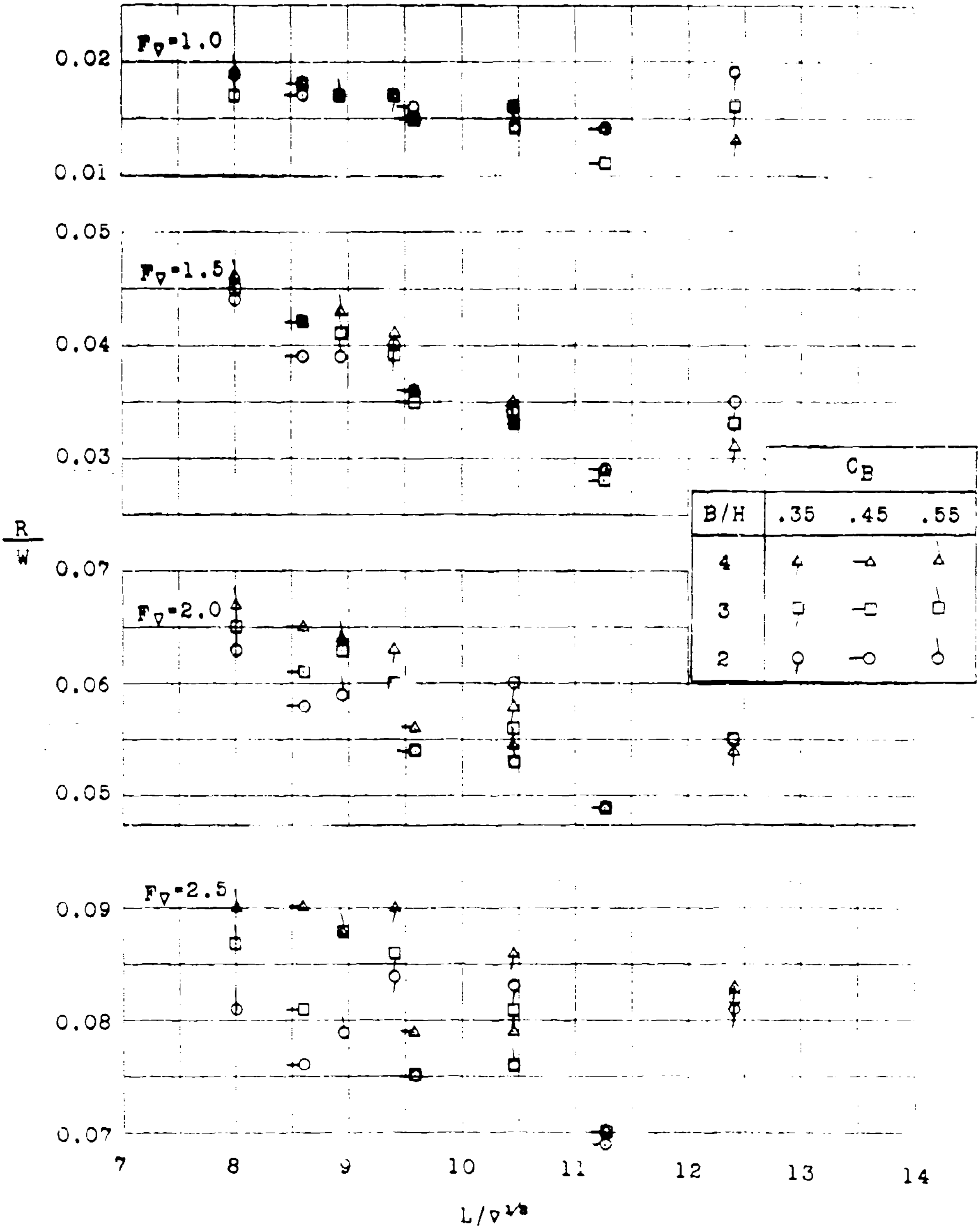


Figure 6a - F_∇ equals 1.0, 1.5, 2.0, and 2.5

Figure 6 - Resistance-Weight Ratio versus Slenderness Ratio with Volume Froude Number as Parameter, for the Hull Forms of Series 64. Resistance Values are for Boats of 200 Tons Gross Weight; ΔC_f = 0.0004

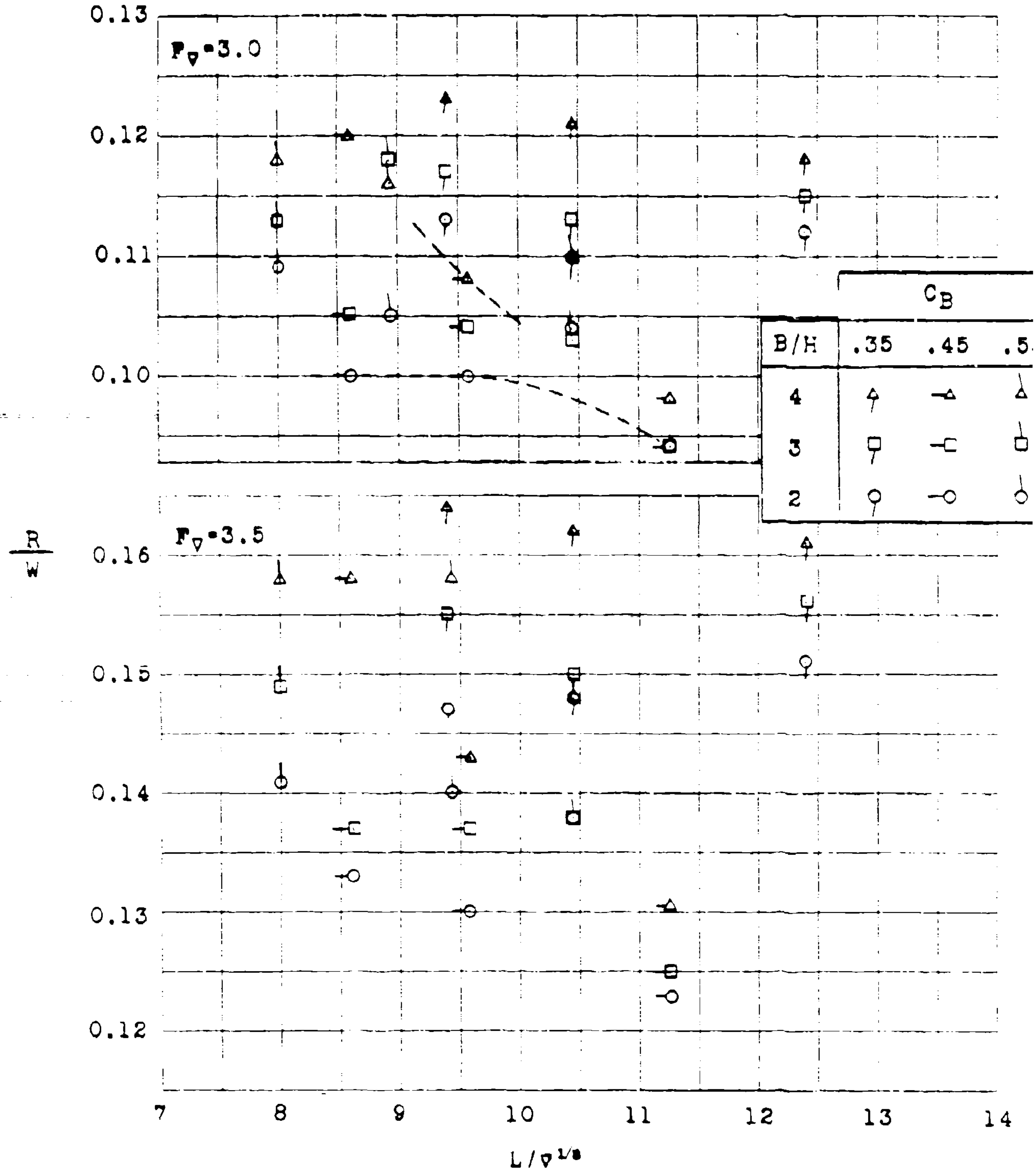


Figure 6b - F_∇ equals 3.0 and 3.5

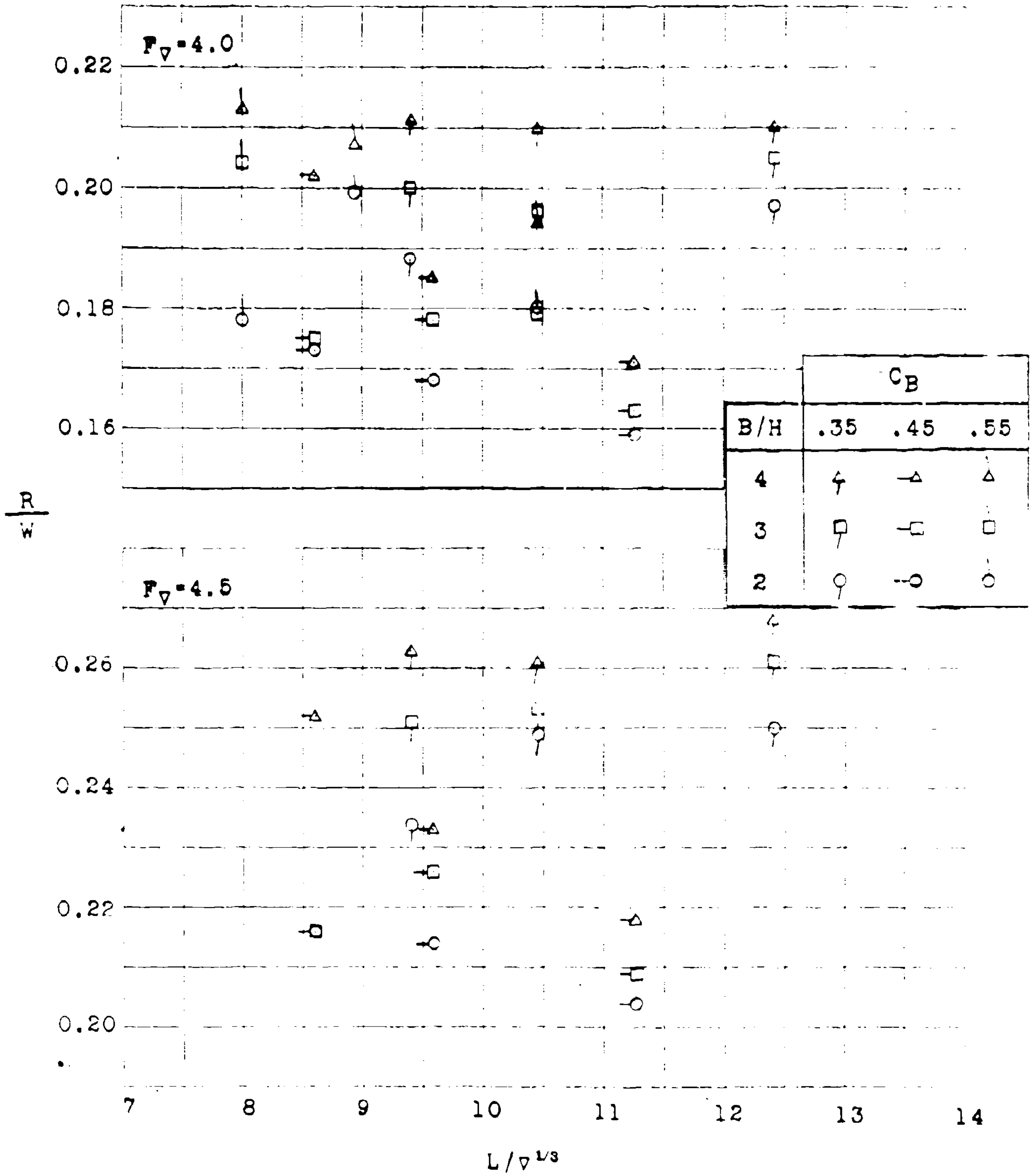


Figure 6c - F_∇ equals 4.0 and 4.5

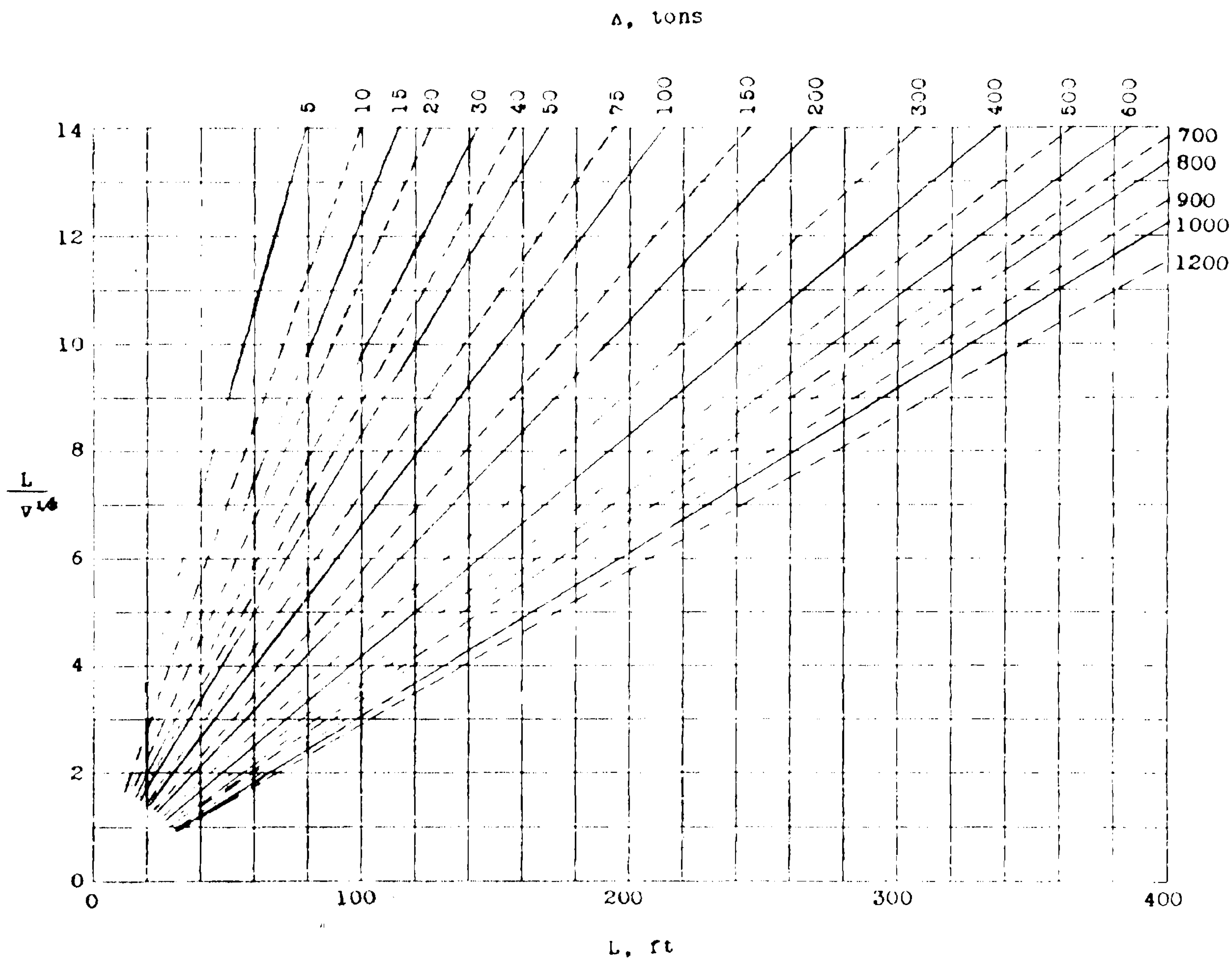


Figure 8 - Relationship of Slenderness Ratio to Length and Displacement

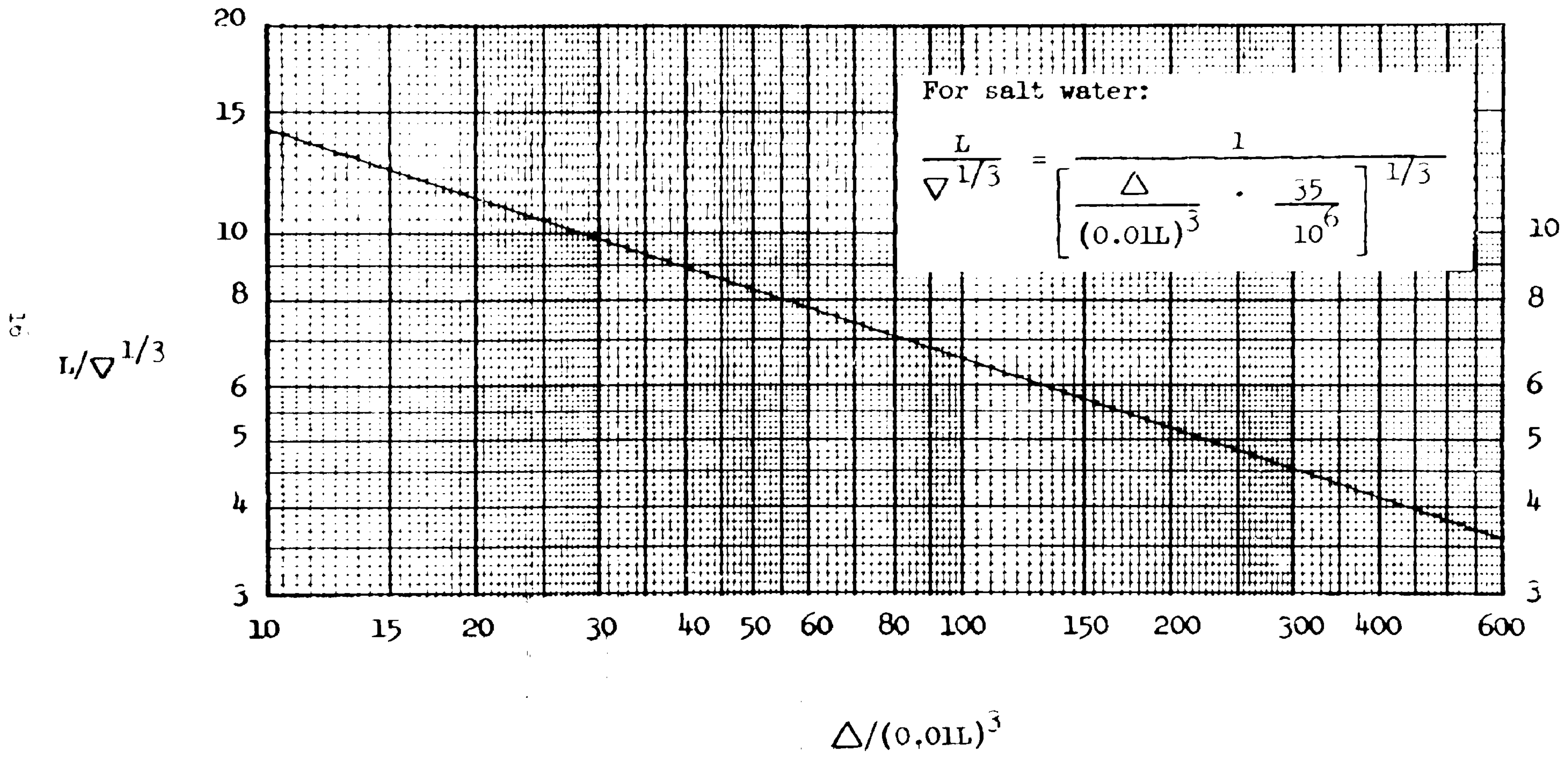


Figure 7 - Relationship Between Slenderness Ratio and Displacement-Length Ratio

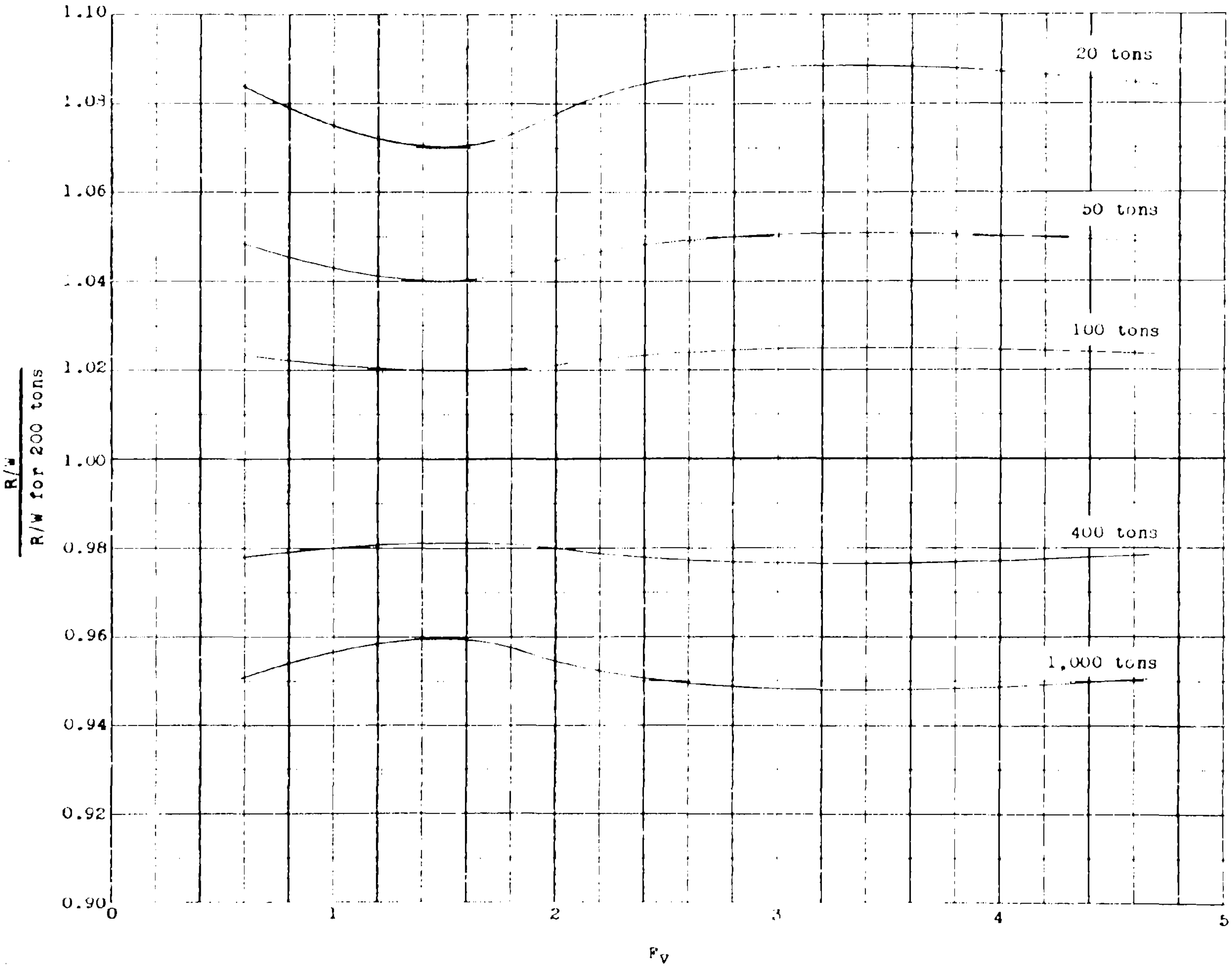


Figure 10 - Values of the Ratio of R/W for Various Displacements to R/W for 200 tons Displacement, from the Test of Model 4797

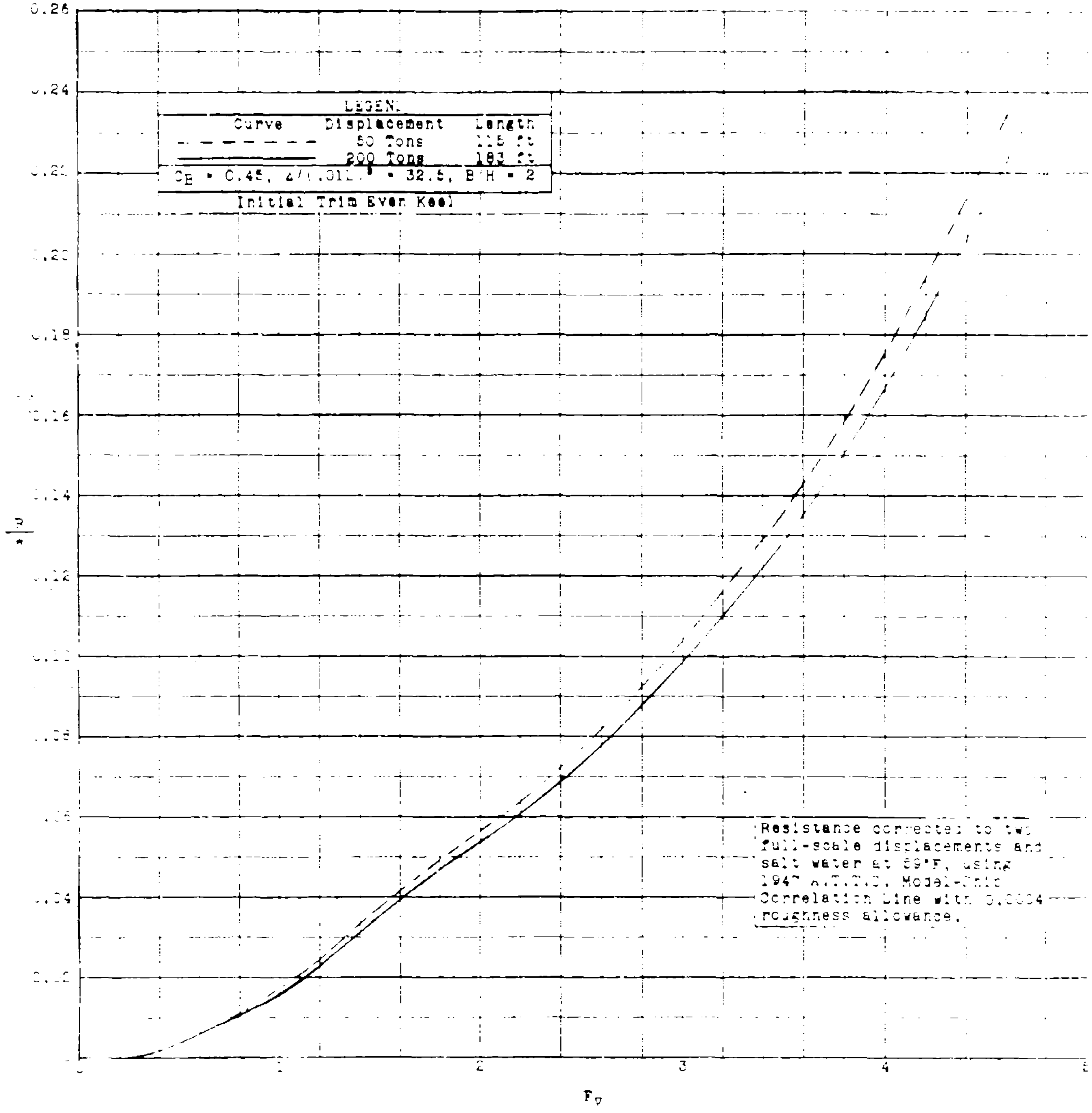


Figure 9 - Values of Resistance-weight Ratio from the Test of Model 4797, for Boat weights of 200 Tons and 50 Tons

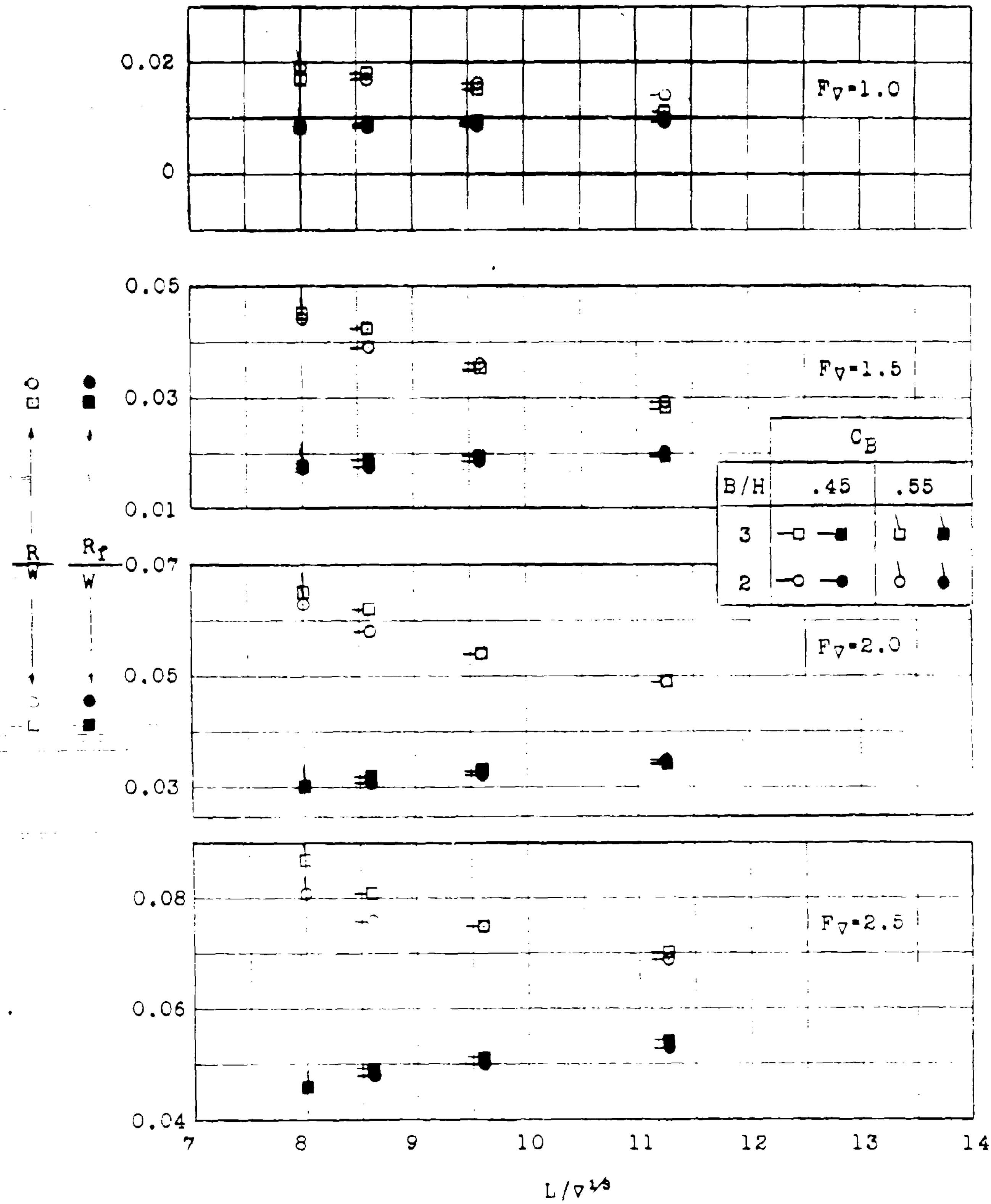


Figure 12a - F_∇ equals 1.0, 1.5, 2.0 and 2.5

Figure 12 - Values of R/W and R_f/W for the More Efficient Hull Forms of Series 64. These Resistance Values are for Boats of 200 Tons Gross Weight; ΔC_f = 0.0004.

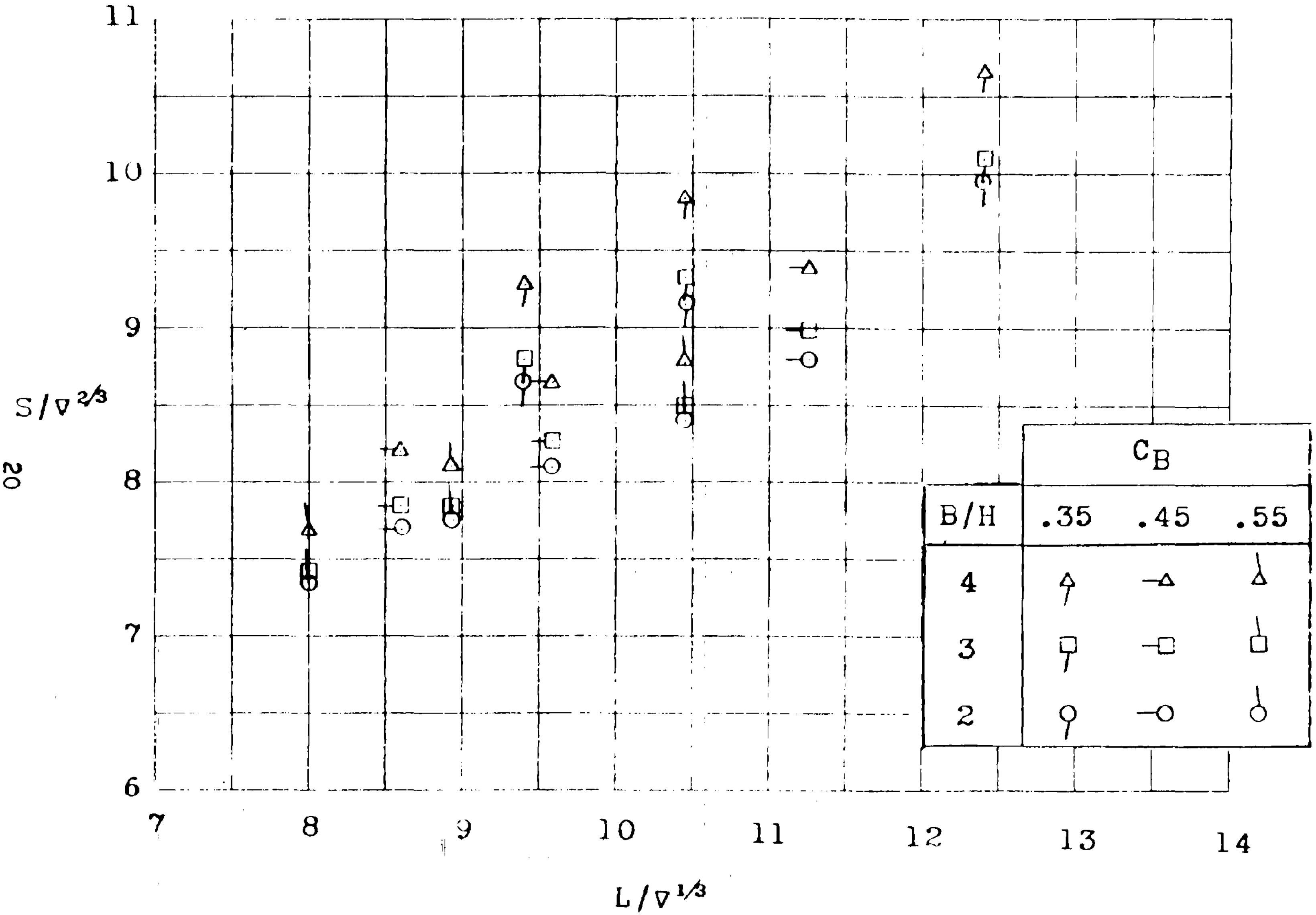


Figure 11 - Values of Wetted Surface Coefficient for the Hull Forms of Series 64.

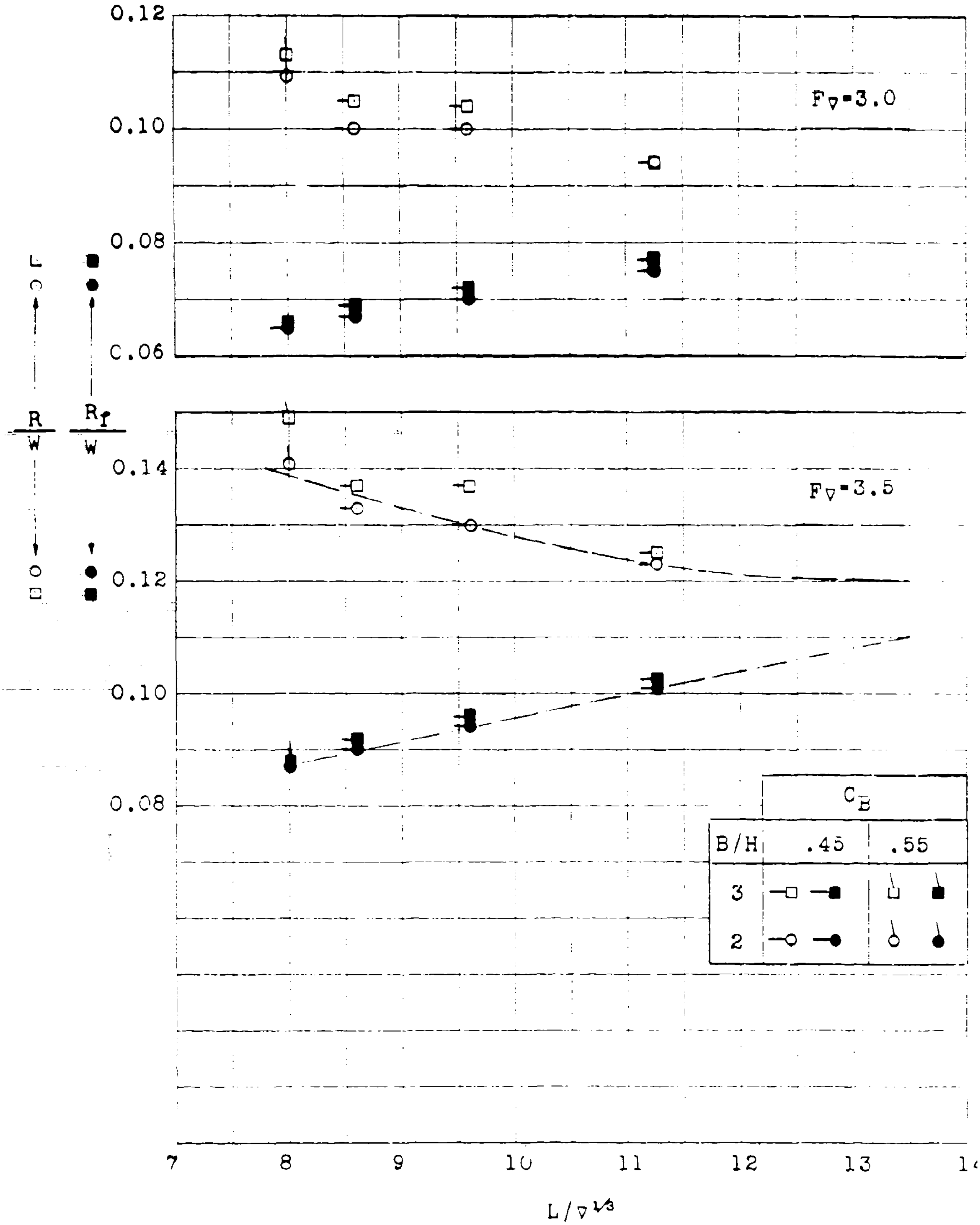


Figure 12b - F_∇ equals 3.0 and 3.5

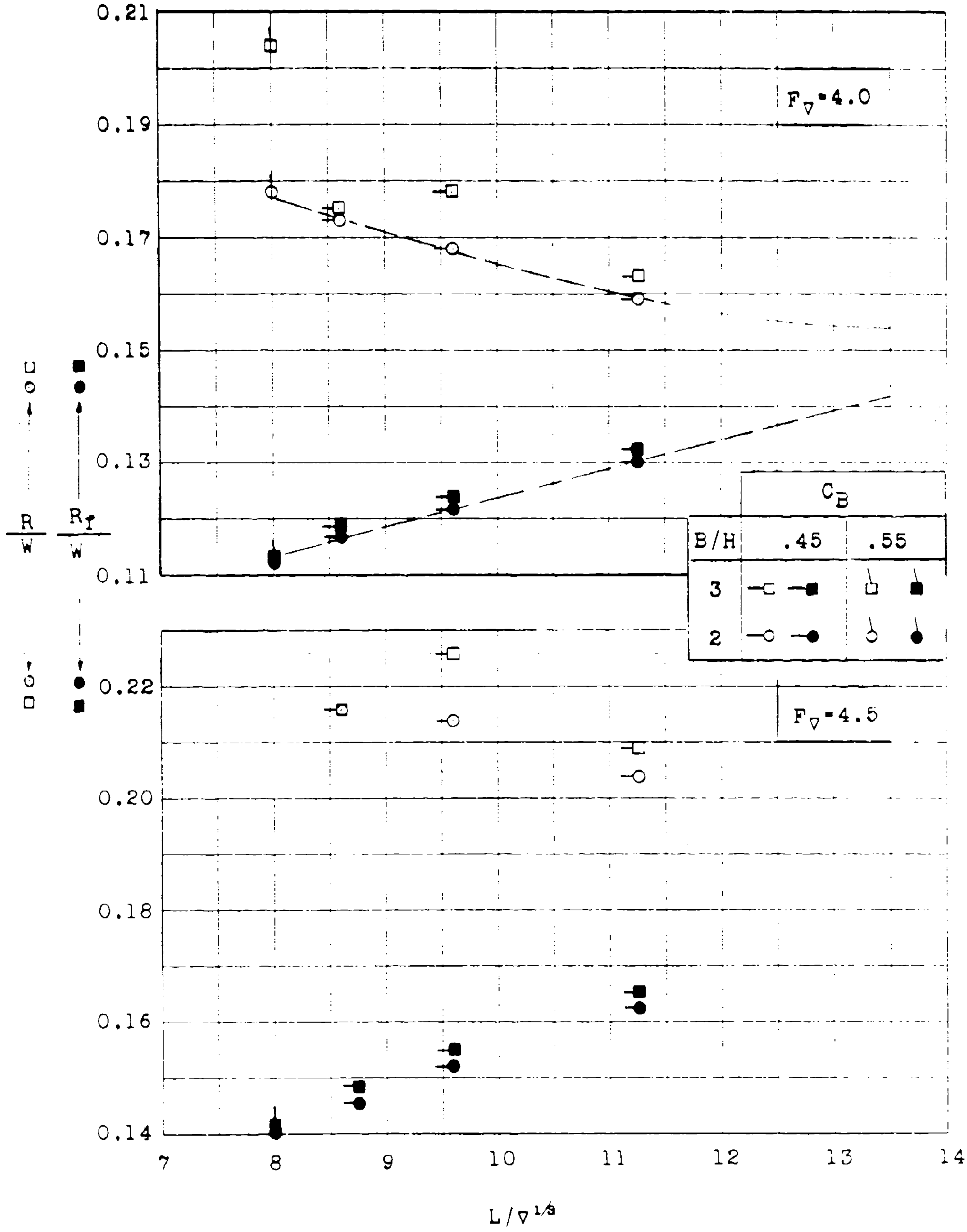


Figure 12c - F_∇ equals 4.0 and 4.5

TABLE I

Form Coefficients for the Hulls of Series 64

LCF/L equals o.601 aft of F.P. and LCB/L equals o.566 aft of F.P. for all models.

C_P equals 0.63 and C_W equals 0.761 for all models.

Model No.	C_B	C_X	$\frac{B_X}{H_X}$	$\frac{\Delta}{(0.01L)^3}$	$\frac{L}{B_X}$	$\frac{1}{2}\alpha_E$
4787	0.55	0.873	2	55	11.956	5.5
4788	0.55	0.873	2	40	14.020	4.7
4789	0.55	0.873	2	25	17.734	3.7
4790	0.55	0.873	3	55	9.762	6.7
4791	0.55	0.873	3	40	11.447	5.8
4792	0.55	0.873	3	25	14.479	4.5
4793	0.55	0.873	4	55	8.454	7.8
4794	0.55	0.873	4	40	9.914	6.6
4795	0.55	0.873	4	25	12.540	5.2
4796	0.45	0.714	2	45	11.956	5.5
4797	0.45	0.714	2	32.5	14.069	4.7
4798	0.45	0.714	2	20	17.934	3.7
4799	0.45	0.714	3	45	9.762	6.7
4800	0.45	0.714	3	32.5	11.487	5.8
4801	0.45	0.714	3	20	14.643	4.5
4802	0.45	0.714	4	45	8.454	7.8
4803	0.45	0.714	4	32.5	9.948	6.6
4804	0.45	0.714	4	20	12.682	5.2
4805	0.35	0.556	2	35	11.956	5.5
4806	0.35	0.556	2	25	14.146	4.7
4807	0.35	0.556	2	15	18.264	3.7
4808	0.35	0.556	3	35	9.762	6.7
4809	0.35	0.556	3	25	11.551	5.8
4810	0.35	0.556	3	15	14.913	4.5
4811	0.35	0.556	4	35	8.454	7.8
4812	0.35	0.556	4	25	10.004	6.6
4813	0.35	0.556	4	15	12.915	5.2

TABLE II

Dimensions of the Models of Series 64

Model No.	B_X in.	H_X in.	A_X in.^{2}	S ft^2	Water Temp.	W_m lb
4787	10.037	5.018	43.96	11.388	71°	120.0
4788	8.559	4.280	31.98	9.711	71.5°	87.2
4789	6.767	3.384	19.99	7.678	76°	54.4
4790	12.292	4.097	43.96	11.503	78.5°	120.0
4791	10.483	3.494	31.98	9.809	69.5°	87.2
4792	8.288	2.763	19.99	7.755	76°	54.4
4793	14.194	3.548	43.96	11.903	68°	120.0
4794	12.104	3.026	31.98	10.151	76°	87.2
4795	9.569	2.392	19.99	8.025	77°	54.4
4796	10.037	5.018	35.97	10.411	68°	98.0
4797	8.529	4.265	25.98	8.848	77.5°	71.0
4798	6.691	3.346	15.99	6.941	75°	43.6
4799	12.292	4.097	35.97	10.616	76°	98.0
4800	10.446	3.482	25.98	9.022	76°	71.0
4801	8.195	2.732	15.99	7.077	78.5°	43.6
4802	14.194	3.548	35.97	11.109	77°	98.0
4803	12.062	3.016	25.98	9.441	78.5°	71.0
4804	9.462	2.366	15.99	7.406	78.5°	43.6
4805	10.037	5.018	27.98	9.907	70°	76.4
4806	8.483	4.242	19.99	8.373	76°	54.4
4807	6.570	3.285	11.99	6.486	76°	32.9
4808	12.292	4.097	27.98	10.089	78.9°	76.4
4809	10.389	3.463	19.99	8.526	78°	54.4
4810	8.047	2.682	11.99	6.604	75°	32.9
4811	14.194	3.548	27.98	10.644	73.5°	76.4
4812	11.996	2.999	19.99	8.996	73.25°	54.4
4813	9.292	2.323	11.99	6.968	72.5°	32.9

Table III - Series 64 - Values of Model Speed and Model Resistance

Table III a - $C_B = 0.55$, $\Delta/(0.01L)^3 = 55$

Model 4787 $B_X/H_X = 2$		Model 4790 $B_X/H_X = 3$		Model 4793 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
1.00	0.18	1.98	0.63	1.02	0.18
1.99	0.62	3.99	3.01	2.00	0.72
3.00	1.55	6.02	6.90	3.01	1.73
4.00	3.00	8.00	9.88	4.00	3.10
5.02	5.20	10.00	13.62	5.00	5.39
6.01	6.75	10.52	14.67	6.00	7.29
7.04	8.23	11.03	15.67	7.04	8.72
8.05	9.64	11.52	16.83	8.00	10.52
9.02	11.22	12.01	18.05	9.00	12.29
10.01	13.06	12.52	19.41	10.00	14.36
11.02	15.31	12.97	20.76	11.00	16.60
12.00	17.54	13.51	22.53	11.99	19.26
13.00	20.18	13.97	24.33	13.00	22.32
14.00	23.10	14.50	26.65	14.00	26.22
1.50	0.38	14.94	28.86	14.99	30.50
2.50	1.08	15.44	31.28	8.51	11.17
3.50	2.19	15.92	33.71	9.51	13.21
4.50	4.16	10.03	13.62	10.55	15.42
5.50	5.98	11.02	15.88	11.51	17.89
6.50	7.45	12.02	18.19	12.53	20.75
7.50	8.86	13.05	21.00	13.48	24.13
8.50	10.35	14.01	24.54	8.02	10.42
9.50	12.03	14.99	24.54		
10.50	14.05	15.95	34.03		
11.50	16.30	15.98	34.28		
12.50	18.87				
13.50	21.64				
14.50	24.55				

Table III b - C_B = 0.55, $\Delta/(0.01L)^3$ = 40					
Model 4788 B_X/H_X = 2		Model 4791 B_X/H_X = 3		Model 4794 B_X/H_X = 4	
V_m	R_m	V_m	R_m	V_m	R_m
1.01	0.18	1.00	0.17	1.05	0.15
2.00	0.57	2.00	0.56	3.00	1.43
3.02	1.31	3.03	1.21	5.03	3.96
4.01	2.35	4.02	2.12	7.02	6.62
5.03	3.86	5.02	3.72	9.02	9.65
6.02	5.07	6.02	5.07	11.01	13.25
7.03	6.20	7.05	6.19	12.98	18.22
8.03	7.46	8.03	7.60	14.88	23.94
9.03	8.74	9.03	9.10	1.98	0.61
10.05	10.33	10.06	10.69	4.00	2.35
11.05	12.21	11.04	12.65	6.03	5.20
12.04	14.21	12.02	14.90	8.10	7.92
1.50	0.30	1.48	0.28	10.04	11.37
2.51	0.89	2.52	0.84	12.04	15.83
4.52	3.14	3.50	1.66	13.71	29.32
5.57	4.56	4.52	2.95	15.86	29.31
6.53	5.61	5.59	4.43	6.03	5.43
7.52	6.76	6.54	5.59	5.54	4.80
8.54	8.02	7.54	6.88	6.51	6.05
9.51	9.55	8.53	8.26	7.50	7.33
10.52	11.24	9.55	9.85	7.00	6.73
11.50	13.15	10.54	11.74	7.48	7.40
13.04	17.50	11.53	13.65	8.03	8.21
14.00	20.22	10.02	10.69	8.54	8.95
15.00	26.40			9.54	10.73
3.51	1.78			10.54	11.95
				14.00	19.83

Table III e - $C_B = 0.55$, $\Delta/(0.01L)^3 = 25$

Model 4789 $B_X/H_X = 2$		Model 4792 $B_X/H_X = 3$		Model 4795 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
12.00	10.58	11.00	8.77	1.00	0.13
2.00	0.41	13.00	12.01	3.01	0.91
4.01	1.56	14.00	14.05	5.02	2.33
8.02	5.05	15.00	16.03	7.02	4.00
6.02	3.30	16.08	18.44	9.00	6.30
10.00	7.52	13.50	13.13	11.03	9.10
13.97	13.91	14.40	14.77	2.00	0.47
0.99	0.11	15.50	17.27	4.00	1.53
3.01	0.92	3.00	0.95	6.02	3.25
5.02	2.30	5.01	2.3[illegible]	8.01	4.76
7.02	4.08	7.02	4.12	10.00	7.70
9.02	6.07	9.11	6.10	8.00	5.10
11.02	8.72	4.00	1.50	11.98	10.82
1.48	0.24	6.02	3.23	12.96	12.46
2.49	0.64	8.05	5.16	13.95	14.36
3.50	1.16	10.01	7.43	14.87	16.45
4.52	1.93	12.00	10.42	15.86	18.80
5.52	2.87			2.49	0.70
6.51	3.66			3.50	1.18
7.52	4.57			4.50	1.91
13.00	11.84			5.49	2.75
				6.02	3.78
				6.50	3.63
				8.00	5.12
				4.51	1.93
				5.00	2.34
				7.00	4.10
				7.51	4.59
				8.00	4.99
				8.49	5.58
				9.50	6.88
				10.00	7.51
				10.50	8.37
				11.50	9.86

Table III 4 - $C_B = 0.45, \Delta/(0.01L)^3 = 45$					
Model 4796 $B_X/H_X = 2$		Model 4799 $B_X/H_X = 3$		Model 4802 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
1.98	0.54	1.98	0.66	1.99	0.66
3.99	2.37	3.98	2.60	3.99	2.37
5.96	5.35	5.97	5.62	5.99	5.62
7.98	7.88	7.96	8.09	8.00	8.46
9.98	10.80	9.97	11.30	10.00	11.99
11.96	14.70	11.95	15.02	12.02	16.20
14.00	19.49	14.04	19.53	14.06	21.94
0.99	0.21	16.08	25.26	16.11	29.76
2.48	1.41	0.99	0.14	0.99	0.16
5.00	4.13	3.00	1.47	2.96	1.42
6.98	6.60	4.98	4.39	4.98	4.11
9.00	9.25	6.98	6.94	7.06	6.95
11.00	12.66	8.99	9.53	8.96	10.10
12.97	16.95	11.00	12.92	10.90	14.17
15.10	22.70	12.80	16.96	13.01	18.90
9.46	9.93	15.08	22.75	11.51	14.96
10.57	11.75	14.55	21.31	11.51	15.16
11.49	13.61	15.60	24.21	13.56	20.40
12.50	15.77	1.99	0.59	15.60	27.41
13.48	17.95	2.99	1.47	15.09	25.52
14.55	21.15	3.00	4.26	2.50	0.94
4.98	4.01	6.00	5.56	3.51	1.81
8.95	9.15	8.98	9.53	11.05	13.84
11.00	12.72	16.00	13.04	15.64	27.49
1.50	0.28	12.98	17.16	10.50	12.95
2.50	0.92			12.57	17.57
3.50	1.79			14.56	23.59
4.52	3.22			10.50	13.01
5.55	4.76			11.09	13.97

Table III e - $C_B = 0.45$, $\Delta/(0.01L)^3 = 32.5$

Model 4797 $B_X/H_X = 2$		Model 4800 $B_X/H_X = 3$		Model 4803 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
1.99	0.49	1.99	0.44	1.99	0.51
3.99	1.87	3.97	1.83	4.00	1.79
5.98	3.99	5.97	3.98	6.00	4.08
7.96	5.93	7.96	6.18	7.97	6.34
10.00	8.49	9.98	8.89	10.00	9.14
11.97	11.50	12.00	12.30	12.02	12.68
14.07	15.82	14.04	16.39	14.07	17.19
16.11	20.69	16.11	21.63	16.09	22.16
0.98	0.09	0.99	0.09	0.98	0.14
3.00	1.10	2.98	1.04	2.99	1.08
5.00	3.01	4.98	2.91	4.98	2.94
6.98	4.93	6.98	4.95	6.98	5.05
8.99	7.25	8.97	7.27	9.00	7.57
11.02	10.12	11.00	10.47	11.00	14.84
13.00	13.61	13.02	14.24	12.97	14.68
7.51	5.40	15.10	19.17	15.08	19.68
9.48	7.70	14.62	17.90	2.50	0.81
11.51	10.98	15.60	20.36	4.49	2.33
13.53	14.63	5.44	3.44	6.50	4.66
15.61	19.42	6.50	4.41	8.51	7.10
1.07	0.06	7.48	5.52	10.51	9.98
		12.50	13.21	12.50	13.69
		4.50	2.34	14.60	18.40
		3.51	1.35	3.50	1.37
		13.50	15.33	5.48	3.48
		14.32	17.10	7.48	5.63
		15.32	19.42	9.44	8.20
				11.50	11.66
				13.52	15.83
				15.63	20.94
				16.07	21.94
				16.05	21.86
				16.10	22.06

Table III f - C_B = 0.45, $\Delta/(0.01L)^3$ = 20

Model 4798 B_X/H_X = 2		Model 4801 B_X/H_X = 3		Model 4804 B_X/H_X = 4	
V_m	R_m	V_m	R_m	V_m	R_m
2.00	0.41	1.99	0.33	1.99	0.36
3.99	1.22	3.99	1.14	4.00	1.21
5.98	2.62	5.99	2.56	6.00	2.63
7.98	4.16	7.97	4.10	8.00	4.22
9.99	6.12	10.00	6.09	10.01	6.36
11.98	8.45	12.01	8.55	11.97	8.86
14.02	11.32	14.04	11.56	14.02	12.13
16.10	14.84	15.06	13.46	16.09	15.81
0.99	0.09	16.10	15.24	0.99	0.06
3.00	0.74	0.99	0.06	2.98	0.77
4.98	1.87	2.99	0.69	5.00	1.91
6.99	3.27	4.99	1.83	7.00	3.36
8.97	4.95	7.00	3.25	8.99	5.19
10.98	7.14	8.99	4.95	11.00	7.52
13.00	9.76	10.97	7.22	13.04	10.40
14.07	11.37	13.00	9.94	15.16	14.04
15.09	13.16	15.62	14.34	8.48	4.66
9.42	5.43	8.48	4.54	9.46	5.60
10.50	6.56	9.49	5.50	10.50	6.83
11.50	7.73	10.52	6.56	11.50	8.18
12.50	9.04	11.49	7.83	12.47	9.56
13.50	10.53	12.50	9.09	13.49	11.36
14.59	12.33	13.50	10.51	14.59	12.96
15.57	13.95	14.65	12.48	15.60	14.95
2.50	0.54	1.50	0.16	3.99	1.22
3.50	0.92	3.99	1.17	8.99	5.19
4.48	1.52	10.00	6.04	9.99	6.36
5.48	2.15			13.53	11.36
6.48	2.85				
7.50	3.60				
8.48	4.47				

Table III g - C_B = 0.35, $\Delta/(0.1L)^3$ = 35					
Model 4808 B_X/H_X = 2		Model 4808 B_X/H_X = 3		Model 4811 B_X/H_X = 4	
V_m	R_m	V_m	R_m	V_m	R_m
1.00	0.10	1.00	0.17	1.00	0.15
2.00	0.55	2.99	1.24	1.99	0.56
3.01	1.20	5.00	3.37	3.00	1.31
4.01	2.10	7.01	5.78	4.00	2.16
5.02	3.52	9.00	8.64	5.00	3.80
6.03	4.72	10.99	12.20	6.02	4.87
7.04	5.91	1.98	0.47	7.00	6.20
8.01	7.19	3.98	2.05	8.00	7.54
9.04	8.62	6.01	4.58	8.98	9.19
10.04	10.30	7.98	7.22	10.00	11.04
11.05	12.05	10.00	10.36	11.00	13.01
12.04	14.02	12.00	14.28	12.00	15.21
13.07	16.19	4.50	2.73	12.96	17.58
14.02	18.55	5.55	4.06	13.96	20.13
1.49	0.27	6.50	5.15	14.92	22.82
2.50	0.84	13.02	16.54	15.91	25.57
3.50	1.63	14.00	19.0[illegible]	3.98	2.14
4.52	2.80	14.98	21.73	10.52	12.15
5.59	4.23	15.95	24.56		
6.53	5.29	14.00	19.10		
7.52	6.30	14.50	20.39		
8.52	7.79	4.00	2.08		
9.55	9.35	5.00	3.38		
10.56	11.05	6.01	4.55		
11.54	12.87				
12.57	14.94				
13.55	17.17				
14.51	19.78				
15.05	20.65				

Table III h - $C_B = 0.35$, $\Delta/(0.01L)^3 = 85$

Model 4806 $B_X/H_X = 2$		Model 4809 $B_X/H_X = 3$		Model 4812 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
1.00	0.12	1.00	0.13	0.99	0.12
3.00	0.92	3.01	0.97	1.98	0.47
5.02	2.43	5.02	2.49	3.03	1.03
7.01	4.37	7.02	4.14	3.98	1.67
9.00	6.56	9.05	6.87	5.00	2.65
8.96	6.63	11.05	9.81	6.00	3.66
11.00	9.47	13.00	13.36	7.00	4.69
13.01	13.24	15.00	17.54	7.99	5.87
14.92	18.54	1.99	0.47	8.99	7.21
2.01	0.45	4.00	1.55	9.99	8.87
3.98	1.58	6.01	3.40	11.00	10.49
6.02	3.48	8.02	5.48	11.97	12.29
8.02	5.47	10.10	8.23	13.01	14.28
10.00	8.04	11.99	11.48	13.97	16.31
12.02	11.33	13.95	15.41	14.94	18.52
4.52	2.00	15.91	19.81	15.91	20.84
5.40	2.99	4.00	1.55	11.49	11.25
5.98	3.40	4.50	1.99	12.48	13.17
6.51	3.87	4.98	2.48		
7.52	4.89	5.50	2.97		
5.00	2.51	6.00	3.38		
5.49	2.95	6.50	3.88		
6.01	3.43	6.99	4.37		
6.50	3.88	7.49	4.90		
7.02	4.37	7.99	5.42		
12.98	13.31	10.00	8.20		
14.00	15.07	10.50	8.97		
13.96	15.16	10.97	9.70		
14.94	17.46	11.50	10.63		
14.49	16.15	11.98	11.38		
		13.05	13.30		
		14.96	17.55		
		8.49	6.08		
		9.00	6.72		
		9.50	7.48		

Table III 1 - $C_B = 0.35$, $\Delta/(0.01L)^3 = 15$					
Model 4807 $B_X/H_X = 2$		Model 4810 $B_X/H_X = 3$		Model 4813 $B_X/H_X = 4$	
V_m	R_m	V_m	R_m	V_m	R_m
1.00	0.10	1.00	0.10	1.00	0.10
2.98	0.71	2.00	0.33	3.00	0.68
5.00	1.79	3.00	0.68	5.00	1.83
7.01	3.17	4.00	1.02	7.01	3.27
9.02	4.94	5.00	1.74	9.00	5.22
11.03	7.46	6.00	2.50	11.02	7.60
12.99	9.81	7.02	3.19	13.00	10.88
15.02	12.91	8.00	4.02	14.92	13.87
1.96	3.70	8.99	5.65	1.98	0.31
3.97	1.16	10.02	7.13	3.98	1.13
6.02	2.40	11.00	8.32	6.00	2.46
8.01	3.96	11.99	8.60	7.99	4.12
9.98	5.99	13.00	10.21	9.95	6.42
11.97	8.38	13.99	11.63	12.00	9.06
14.02	11.35	14.95	13.31	13.95	12.08
15.94	14.55	1.50	0.19	15.90	15.82
1.48	0.20	2.50	0.49	11.99	9.00
3.50	0.90	3.50	0.88	4.50	1.43
5.55	2.09	4.52	1.35	5.50	2.14
7.50	3.50	5.55	2.14	13.00	10.51
9.51	5.41	6.51	3.82	5.00	1.73
11.48	7.75	7.50	3.70	7.00	3.27
13.44	10.41	8.50	4.43	15.92	15.81
15.41	13.65	9.50	5.57		
2.48	0.64	10.50	6.87		
4.51	1.45	11.49	8.04		
6.50	2.77	12.48	9.80		
8.50	4.37	13.48	10.88		
10.53	6.56	14.40	12.41		
12.48	9.10	15.41	14.10		
11.43	11.97	11.00	7.32		
		8.99	5.02		
		9.99	6.12		
		11.50	7.97		
		15.95	15.15		

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13 ABSTRACT

Values of residuary resistance from model tests were previously presented for a methodical series of slender displacement hull forms which had been tested up to high speeds. The present report gives values of total resistance for the hull forms of the series so that their relative merits can readily be seen. The values of total resistance were calculated for boats of 200-ton displacement to facilitate comparison with resistance data for U. S. Navy hydrofoil boats. The form of the data presentation is such as to provide guidance for the design of high-speed displacement and catamaran hull forms.

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13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

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